

# Saturn Entry Probe Potential

## *for Uranus and Neptune Missions*

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# Organization

JPL

- Science objectives for Saturn, Uranus, & Neptune entry probe missions
  - From the US 2012 Planetary Science Decadal Survey (PSDS)
- Entry probe mission characteristics at these destinations
- Conclusions



# PSDS Saturn Probe Science Objectives



## ■ “Highest Priority”

- Determine the noble gas abundances and isotopic ratios of H, C, N, and O in Saturn's atmosphere
- Determine the atmospheric structure at the probe descent location

## ■ “Lower Priority”

- Determine the vertical profile of zonal winds as a function of depth at the probe descent location(s)
- Determine the location, density, and composition of clouds as a function of depth in the atmosphere
- Determine the variability of atmospheric structure and presence of clouds in two locations
- Determine the vertical water abundance profile at the probe descent location(s)
- Determine precision isotope measurements for light elements such as S, N, and O found in simple atmospheric constituents



# PSDS Uranus Probe Science Objectives



## ■ “Medium Priority”

- Determine the noble gas abundances (He, Ne, Ar, Kr, and Xe) and isotopic ratios of H, C, N, and O in the planet’s atmosphere and...
- the atmospheric structure at the probe descent location

## ■ “Lower Priority”

- Determine the vertical profile of zonal winds as a function of depth in the atmosphere, in addition to...
- the presence of clouds as a function of depth in the atmosphere



# PSDS Neptune Probe Science Objectives



- Not specified in the PSDS
- Likely similar to Uranus objectives
  - Consistent with science priorities in 2003-2004 NASA Vision Missions studies
  - High Triton science priority might limit trajectory design options
    - Triton's orbit is retrograde, inclination  $157^\circ$



# Saturn Entry Probe Science Objectives: What's the Big Picture?

JPL

## ■ Composition Measurements

- Clues to the composition of the presolar nebula
- Giant planet and solar system formation processes and timeline
- Critical component of understanding Saturn's thermal evolution (He), heat flow, and radiation balance
- Search for chemical evidence of planetary migration
- *Need to penetrate to the 5-10 bar level*

## ■ Atmospheric Structure Measurements

- Context for the composition measurements
- Atmospheric heat flow and radiation balance
- Energy source(s) for deep zonal winds
  - Depth of solar energy deposition
- Static stability, propensity for convective mixing

# Progress in Solar System Origins Research from Giant Planet Comparative Planetology

Data Set Needed for Meaningful Comparisons

Planet -->	Jupiter	Saturn
Investigation		
Atmospheric Composition		
Interior Structure		

Green Background: Data already in hand

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Blue Background:

Data planned from a mission already in flight

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Interior Structure	<i>Juno</i>	<i>Cassini</i> Proximal Orbits

Blue Background:

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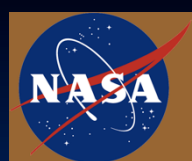
# Progress in Solar System Origins Research from Giant Planet Comparative Planetology

Data Set Needed for Meaningful Comparisons

Planet --> Investigation	Jupiter	Saturn
Atmospheric Composition	<i>Galileo Probe</i>	Saturn Probe
Interior Structure	<i>Juno</i>	<i>Cassini</i> Proximal Orbits

Yellow Background:

No mission yet approved to acquire data,  
but recommended by 2012 Decadal Survey



# Bulk Characteristics of the Giant Planets

Characteristic Planet	Mass (Earth masses)	Equatorial radius (km)	Mean mass density (gm/cm <sup>3</sup> )
Jupiter	317	71490	1.32
Saturn	95	60330	0.68
Uranus	14.5	25500	1.27
Neptune	17.1	24770	1.64

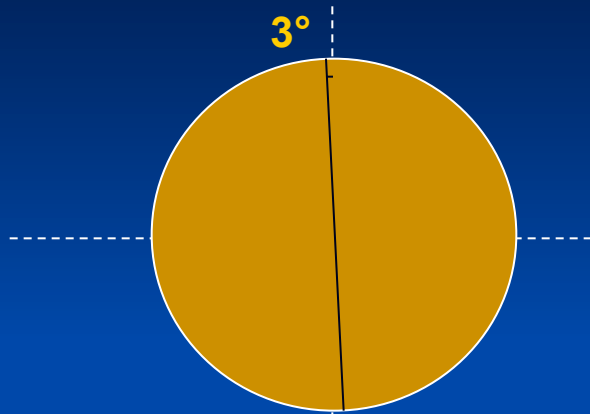


# Bulk Characteristics of the Giant Planets

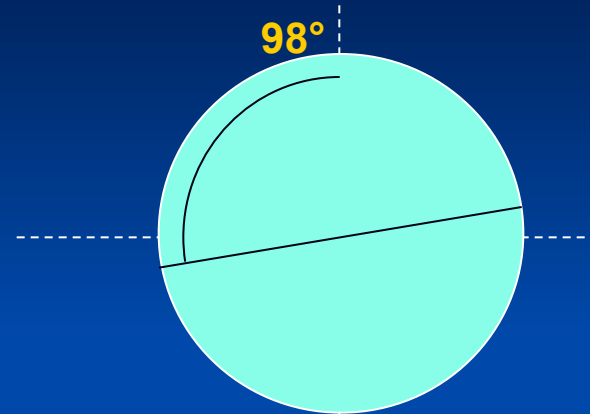
Characteristic Planet	Atmospheric Helium Abundance	Icy Element Abundance (x Solar)	Tropopause Temperature (K)
Jupiter	11-12%	3-6	110
Saturn	13±5%	5-10?	90
Uranus	18%?	20-50?	50
Neptune	18%?	20-50?	50



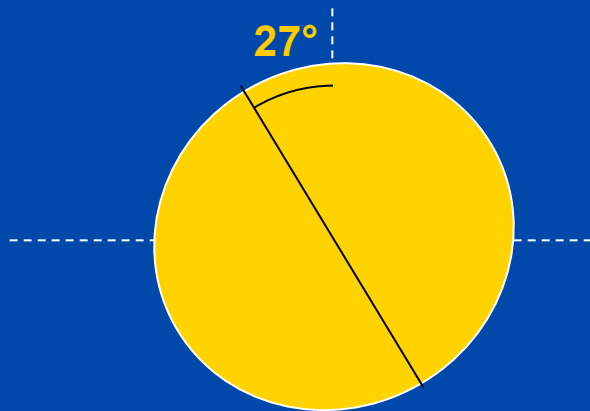
# Obliquities of the Giant Planets



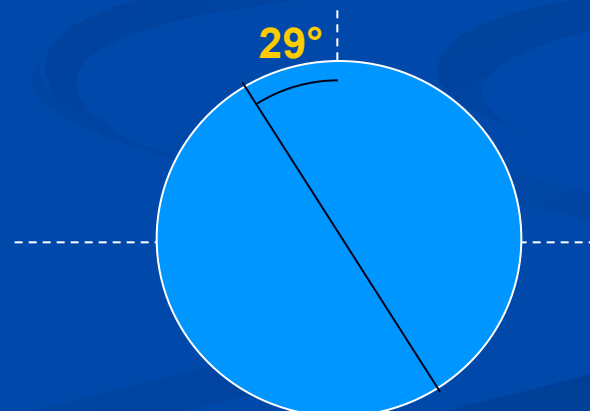
Jupiter



Uranus



Saturn



Neptune



# Typical Atm-Relative Entry Speeds At the Giant Planets

Speeds in km/s; assume “typical” hyperbolic approach  $V_{\infty}$

Entry Orbit Inclination Destination	0° (prograde)	90° (polar)	180° (retrograde)
Jupiter	47.4	59.8	72.4
Saturn	26.8	36.5	46.3
Uranus	21.5	24.0	26.6
Neptune	25.5	28.2	30.8

*Color-coded entry condition indicators assume shallow entry angle*



# Conclusions

- High-priority entry probe science objectives at Uranus & Neptune are similar to those at Saturn
  - Can be addressed by similar instrumentation
- In most entry circumstance cases, entry conditions for Uranus or Neptune entries are similar to Saturn conditions
- Simple descent module thermal design could accommodate differences in tropopause temperatures
- Program of entry probes to Saturn, Uranus, & Neptune would be cost-effective and provide exceptional science value



**Questions?**